



Basal medial opening wedge first metatarsal osteotomy stabilized with a low profile wedge plate

Sujit KUMAR, Sujith KONAN, Michael J. ODDY, Rohit T. MADHAV

From University College Hospital, London, U.K.

Twenty patients underwent 25 basal medial opening wedge osteotomies of the first metatarsal stabilized using a low-profile wedge plate in combination with a distal soft tissue release, distal metatarsal osteotomy and Akin osteotomy as required for correction of a hallux valgus deformity. The mean clinical and radiographic follow-up was 12.2 months. Pre- and post operative radiographs available in 15 cases showed that the median hallux valgus angle (HVA), inter-metatarsal angle (IMA) and distal metatarsal articular angle (DMAA) were corrected from 45.5 to 13.1, 17.7 to 9.2 and 24.3 to 10.0 degrees respectively ($p < 0.001$). Final radiographic assessment for the whole series showed a median final HVA and IMA of 14.1 and 9.1 respectively. Radiographic union was noted in all but one case which was asymptomatic. One wound infection was treated with oral antibiotics, one hallux varus deformity required soft tissue reconstruction and there was one recurrence. The outcome was reported as good or satisfactory by the patients for 20 of 25 feet. Three patients reported stiffness in the first MTP joint, which improved with joint injection and manipulation. Two plates were removed for prominence. The basal medial opening wedge osteotomy stabilized with a low profile wedge plate was an effective addition for correcting a moderate to severe hallux valgus deformity as part of a double or triple first ray osteotomy.

Keywords : hallux valgus ; basal osteotomy ; first metatarsal ; plate fixation.

INTRODUCTION

Numerous surgical techniques have been described for the correction of a hallux valgus deformity including osteotomies involving the head, shaft or base of the first metatarsal combined with soft tissue reconstruction (8). The severity and nature of the deformity may require a combination of procedures to achieve the necessary correction. From a mechanical point of view, a proximal metatarsal osteotomy acts via a long axis of rotation and can achieve a high degree of correction making it a useful procedure for moderate to severe hallux valgus deformity with an inter-metatarsal angle (IMA) and a hallux valgus angle (HVA) of greater

-
- Sujit Kumar, MRCS, Specialist Registrar.
 - Sujith Konan, MRCS, Specialist Registrar.
 - Michael J. Oddy, MA MSc FRCS (Tr. & Orth.), Consultant Trauma and Orthopaedic Surgeon.
 - Rohit Madhav, FRCS (Tr. & Orth.), Consultant Trauma and Orthopaedic Surgeon.

Department of Trauma and Orthopaedics, UCL Hospitals NHS Foundation Trust, University College Hospital, London, U.K.

Correspondence: Michael J. Oddy, Department of Trauma and Orthopaedics, UCL Hospitals NHS Foundation Trust, University College Hospital, 235 Euston Road London NW1 2PQ, U.K. E-mail: mike.oddy@uclh.nhs.uk

© 2012, Acta Orthopædica Belgica.

than 13 and 30 degrees respectively (5,17). A basal osteotomy has also been described in conjunction with a distal metatarsal osteotomy and an Akin medial closing wedge proximal phalangeal osteotomy as *double* and *triple* first ray osteotomies respectively (3).

A number of techniques of basal osteotomy can be performed including crescentic (12,21), chevron (15), closing wedge (9,20) and opening wedge (16,19). Early descriptions of a basal medial opening wedge osteotomy used the bone resected from the medial eminence to fill in the gap created by a transverse opening wedge with no internal fixation (18). Internal fixation methods to improve stability of the osteotomy include Kirschner wires, bone screws and headless differential pitch screws (9). However, these techniques can have poor control in the small proximal fragment leading to dorsal mal-union in up to 25% of cases with subsequent transfer metatarsalgia (20).

Contemporary plate fixation is available (16,18) and the aim of this study was to review our clinical and radiographic results of a consecutive series of 25 cases of a medial open wedge basal osteotomy using a low profile wedge plate and to report its use in cases of double and triple first ray osteotomies (3).

PATIENTS AND METHODS

We reviewed a consecutive series of 20 patients (16 female, 4 male ; mean age 52.6, range 15 to 76 years) who underwent a basal medial opening wedge osteotomy of the first metatarsal for correction of hallux valgus using a low profile wedge plate. All cases were performed by, or under the direct supervision of one consultant (RTM). Pre-operative planning assessed severity of the deformity, joint congruence and the distal metatarsal articular angle (DMAA). According to the pre-operative plan and intra-operative correction assessed clinically and fluoroscopically, the basal osteotomies were performed in combination with a distal soft tissue release with or without a distal extended chevron metatarsal osteotomy and a closing wedge Akin osteotomy of the proximal phalanx. Five patients underwent bilateral procedures providing 25 feet for follow-up. The mean clinical follow-up was 12.2 months (range 4-48). In 5 cases, the basal osteotomy was performed as a revision procedure for recurrence after failed distal metatarsal or scarf osteotomy.



Fig. 1. — Intra-operative photograph of wedge plate *in situ*

Operative technique

All cases were performed under general anaesthesia with ankle block and an ankle tourniquet. All patients received intra-venous 1.5 g Cefuroxime at induction. A medial incision was made along the shaft of the first metatarsal protecting the dorso-medial cutaneous nerve. A capsulotomy of the first metatarso-phalangeal joint allowed a lateral release of the adductor hallucis and lateral metatarso-sesamoid ligament. The medial eminence of the metatarsal head was resected and a medial opening wedge osteotomy of the first metatarsal was performed using a power saw parallel and 10 mm from the metatarso-cuneiform joint whilst leaving the plantar-lateral cortex intact. The osteotomy was opened dorso-medially achieving plantar and lateral displacement and was stabilized using a low profile L-shaped titanium wedge plate and four screws (Low Profile Plate and Screw System™ Arthrex®). These plates have a central wedge ranging between 2 mm to 5 mm (with increments of 0.5 mm). The size of the wedge had been estimated by pre-operative planning and confirmed using intra-operative fluoroscopy. The plates were positioned dorso-medially to maintain the plantar-medial displacement (Fig. 1). The osteotomy gap surrounding the wedge was filled with local graft from the medial eminence.

In 23 cases a bi-planar extended chevron distal osteotomy was performed and fixed with a single screw to achieve further correction and correct the DMAA (Fig. 2 a & b). In 13 cases, an Akin medial closing wedge osteotomy of the proximal phalanx was performed and stabilized with either a toe staple or a single screw ; in 11



Fig. 2. — a : Pre-operative radiograph showing severe hallux valgus deformity ; b : Post-operative radiographs after a double first ray osteotomy.

of these, the Akin was performed in addition to the basal and distal osteotomies.

A medial capsulorrhaphy was performed centred around the estimated centre of rotation of the metatarsal head, the wound closed with sub-cuticular Vicryl rapide and a compression bandage applied. Patients were allowed to bear weight immediately in a reverse camber shoe, returning to a flat shoe from six weeks post-operation.

Assessment

Clinical evaluation at final follow-up was performed using the American Orthopaedic Foot and Ankle Society (AOFAS) Hallux score (11), the Foot Function Index (FFI) (1) and the Manchester-Oxford Foot Questionnaire (MOXFQ) (7). In addition, patients were asked to rate the result of their operation as good, satisfactory or poor. Weight-bearing dorso-plantar and lateral radiographs of the feet were performed pre-operation and at final follow up. The HVA, IMA, DMAA and joint congruence were recorded (4,6). The sesamoid location was based on the seven positions (1 to 7) of the medial sesamoid in relation to the midline of the first metatarso-phalangeal joint (with 4 being on the midline) (10). Change in metatarsal

length was calculated based on Mitchell's formula (13). Sagittal plane first metatarsal alignment was assessed using talo-first metatarsal co-linearity (Meary's angle), with a positive angle indicating declination.

Statistics

Data were analysed using SPSS for Windows (v.12.0). A Wilcoxon signed rank test was used to compare data pre- and post-operation with a p value < 0.05 considered significant.

RESULTS

Clinical Outcome

The osteotomy was stabilized using a 4 mm, 4.5 mm or 5 mm plate in all cases. One patient had a superficial wound infection which was treated with oral antibiotics and resolved uneventfully. The outcome of 16 (64%) and four (16%) osteotomies were rated by the patients as good and satisfactory respectively (total 80%). Three patients experienced stiffness in the hallux metatarso-phalangeal

(MTP) joint. In two of these the symptoms improved to a good result after manipulation under anaesthesia whilst the other patient accepted the outcome without further intervention. Two plates were removed for prominent metal. Two osteotomies had poor outcomes : one hallux varus deformity required soft tissue reconstruction and one recurrence of a hallux valgus deformity required revision to a tarso-metatarsal arthrodesis. The median AOFAS score at final follow-up was 85 (range 63 to 100). The median FFI at final follow-up was 11.5 (range 0 to 45). The median MOXFQ score at final follow-up was 15.0 (range 1 to 36).

Radiographic Outcome

At final follow-up radiographic union was noted in all but one case which was asymptomatic. The introduction of digital radiography and a Picture Archive Communication System (PACS) with loss of some hard copy radiographs meant that at final review, pre- and post-operative weight-bearing radiographs were available for only 15 osteotomies. The median (with 95% confidence intervals (CI)) for the pre- and post-operative HVA were 45.5 (33.4-49.0) degrees and 13.1 (12.1-20.3) degrees respectively ($p = 0.001$). The median (with 95% CI) for the pre- and post-operative IMA were 17.7 (14.0-18.9) degrees and 9.2 (6.5-11.6) degrees respectively ($p = 0.001$). The median (with 95% CI) for the pre- and post-operative DMAA were 24.3 (17.7-29.8) degrees and 10.0 (7.9-14.9) degrees respectively ($p = 0.003$). For the whole series, based only on final radiographic data, the mean (with 95% CI) HVA and IMA were 14.1 (7.8-19.0) degrees and 9.1 (7.4-11.1) degrees respectively. For the 15 with complete data, the sesamoid position was corrected from a median (with 95% CI) pre-operative grade of 3.0 (2.1-2.8) to 1.0 (0.9-1.9) post-operation ($p = 0.006$). First MTP joint congruence increased from 20% pre-operatively to 64% postoperatively. There was a median (with 95% CI) shortening of the first metatarsal of 4.8 mm (3.3-7.0 mm). The median pre- and post-operative (with 95% CI) talo-first metatarsal Meary's angles were 6.4 (4.9-12.1) degrees and 6.3 (5.3-11.1) degrees respectively ($p = 0.910$).

DISCUSSION

Basal first metatarsal osteotomy by a number of techniques has been shown to correct a moderate to severe hallux valgus deformity with satisfaction in excess of 80% (12,15,21). However, since a basal osteotomy can produce a powerful angular correction, hallux varus rates as high as 12 to 19% have been reported (12,20). Advantages and disadvantages of the different types of proximal osteotomy have been reviewed previously (14,17,19). One of the main disadvantages of a basal first metatarsal osteotomy without rigid fixation is dorsal malunion with the elevated first ray leading to transfer metatarsalgia. In this series we have demonstrated that talo-first metatarsal (Meary's angle) co-linearity was maintained with no significant differences between pre and post-operative values. A specific advantage of a medial opening wedge osteotomy is that metatarsal shortening should be avoided. An *in vitro* study of a basal medial opening wedge first metatarsal osteotomy has showed only a 1 to 2.5% length increase (2) and thus in clinical practice it probably only maintains length but should, nevertheless, reduce potential transfer metatarsalgia (8).

In this study we have demonstrated a reduction in HVA and IMA to final median values of 13.1 and 9.2 degrees. The results of our study compare favourably with two previous reports (16,18) of the use of a similar wedge plate for a basal medial opening wedge osteotomy and confirm that a reproducible, stable correction can be achieved for moderate and severe hallux valgus deformity with an acceptable complication rate. The single case of a reducible hallux varus amounts to a rate of 4% compared with 7.8% in another series using a similar implant (18). The patient with hallux varus underwent a medial soft tissue release and extensor hallucis brevis tendon transfer and subsequently had a good outcome with a mobile and well aligned hallux (Fig. 3 a-c).

A basal osteotomy in isolation can increase the DMAA and in this series of cases we paid particular attention to correcting an elevated DMAA ; our series, therefore, reports the use of the basal wedge plate in the presence of additional distal osteotomy and Akin as required : a double or triple first ray



Fig. 3. — a : Pre-operative radiograph of severe hallux valgus deformity ; b : Post-operative photograph after soft tissue reconstruction to correct hallux varus deformity ; c : Post-operative radiograph demonstrating final correction.

osteotomy. Our series had a median DMAA of 24.3 degrees pre-operation and all but two cases had a bi-planar distal chevron osteotomy to correct the DMAA to a median of 10.0 degrees post-operation. An earlier report of double and triple first ray osteotomies demonstrated an 81% satisfaction rate in a series of 21 cases using a crescentic basal osteotomy stabilized with a Kirschner wire and cancellous screw (3). Our patient rating of the outcome of surgery as good or satisfactory in 80% of cases

thus compares favourably. The results of the AOFAS hallux score with a mean of 84 in our study compared similarly to another report using this implant.

In the authors' experience, lengthening of the first metatarsal can result in first metatarso-phalangeal joint instability, increased joint reaction forces on articular surfaces that often have early degenerative changes, with resultant stiffness and dysfunction. Therefore some shortening via the

distal osteotomy was undertaken as required to balance the first metatarso-phalangeal joint, correct the DMAA and maintain weight-bearing through the first ray, thus avoiding transfer metatarsalgia.

In our series, 23 out of 25 osteotomies were double osteotomies for correction of the DMAA with a median first metatarsal shortening of 4.8 mm. Although this negated the advantages of a medial opening wedge osteotomy in maintaining length of the first metatarsal, by incorporating and achieving predictable plantar displacement, none of our patients developed transfer metatarsalgia and there were no radiographic cases of dorsal mal-union. This compares to a series using this implant with no distal metatarsal osteotomy where the mean lengthening of the first metatarsal was 2.3 mm (18).

The combination of double or triple first ray osteotomies as described in this series was used in 5 revision cases. Four of these cases had previously undergone a scarf osteotomy and the other case was a recurrence of deformity after a distal metatarsal osteotomy. Two of these cases in one patient required first metatarso-phalangeal joint injection and manipulation for stiffness but resulted in good satisfaction at final follow-up. The other three revision cases were all associated with good satisfaction clinically and radiographically.

We acknowledge that the series reported here is unfortunately affected by the loss of radiographic data due to the transition from hard copy to digital radiography and a PACS system. We have thus presented clearly the sub-grouping of those 15 osteotomies with pre- and post-operative weight-bearing radiographs and the whole group based on only post operative radiographs. The clinical outcomes including complications are based on the complete series which we feel to be a useful contribution to evidence regarding this implant and its use in hallux valgus correction.

The treatment of a moderate to severe hallux valgus with an elevated DMAA can be a challenging deformity to correct and cannot be addressed with a basal osteotomy alone which will worsen an elevated DMAA. A scarf osteotomy with translation and differential rotation is a viable alternative to a double first ray osteotomy but the amount of correction and de-rotation may be limited by the width of the

bone and the correction may be sub-optimal in a large deformity. In this study we have demonstrated that the combination of a basal medial opening wedge osteotomy of the first metatarsal stabilized with a low profile wedge plate in conjunction with a distal metatarsal and Akin osteotomy is a stable and effective method for correcting a moderate to severe hallux valgus deformity.

REFERENCES

1. **Budiman-Mak E, Conrad KJ, Roach K.** The Foot Function Index : A measure of foot pain and disability. *J Clin Epidemiology* 1991 ; 4 : 561-570.
2. **Budny AM, Masadeh SB, Lyons MC, Frania SJ.** The opening base wedge osteotomy and subsequent lengthening of the first metatarsal : an in vitro study. *J Foot Ankle Surg* 2009 ; 48 : 662-667.
3. **Coughlin MJ, Carlson RE.** Treatment of hallux valgus with an increased distal metatarsal articular angle : evaluation of double and triple first ray osteotomies. *Foot Ankle Int* 1999 ; 20 : 762-770.
4. **Coughlin MJ, Freund E.** The reliability of angular measurements in hallux valgus deformities. *Foot Ankle Int* 2001 ; 22 : 369-379.
5. **Coughlin MJ, Mann RA.** Hallux Valgus. In : Coughlin MJ, Mann RA, Saltzman CL (eds). *Surgery of the Foot and Ankle*. 8th edition, Vol 1. Mosby Elsevier 2007, pp 183-363.
6. **Coughlin MJ, Saltzman CL, Nunley, JA.** Angular measurements in the evaluation of hallux valgus deformities : a report of the ad hoc committee of the American Orthopaedic Foot and Ankle Society on angular measurements. *Foot Ankle Int* 2003 ; 23 : 68-74.
7. **Dawson J, Coffey J, Doll H et al.** A patient-based questionnaire to assess outcomes of foot surgery : validation in the context of surgery for hallux valgus. *Qual Life Res* 2006 ; 15 : 1211-1222.
8. **Easley ME, Trnka HJ.** Current concepts review : hallux valgus part II : operative treatment. *Foot Ankle Int* 2007 ; 28 : 748-758.
9. **Fadel GE, Hussain SM, Sripada S, Jain AS.** Fixation of first metatarsal basal osteotomy using Acutrak screw. *Foot Ankle Surgery* 2008 ; 14 : 12-25.
10. **Hardy RH, Clapham JCR.** Observation on hallux valgus. Based on a controlled series. *J Bone Joint Surg* 1951 ; 33-B : 376-391.
11. **Kitaoka HB, Alexander IJ, Adelaar RS et al.** Clinical rating systems for the ankle-hindfoot, midfoot, hallux and lesser toes. *Foot Ankle Int* 1994 ; 15 : 349-353.
12. **Mann RA, Rudicel S, Graves SC.** Repair of hallux valgus with a distal soft-tissue procedure and proximal metatarsal osteotomy. *J Bone Joint Surg* 1992 ; 74-A : 124-129.

13. **Mitchell CL, Fleming JL, Allen R et al.** Osteotomy-bunionectomy for hallux valgus. *J Bone Joint Surg* 1958 ; 40-A : 41-60.
14. **Nyska M, Trnka HJ, Parks BG, Myerson MS.** Proximal metatarsal osteotomies : a comparative geometric analysis conducted on sawbone models. *Foot Ankle Int* 2002 ; 23 : 939-945.
15. **O'Donnell T, Hogan N, Solan M, Stephens MM.** Correction of severe hallux valgus using a basal chevron osteotomy and distal soft tissue release. *Foot Ankle Surgery* 2010 ; 16 : 126-131.
16. **Randhawa S, Pepper D.** Radiographic evaluation of hallux valgus treated with opening wedge osteotomy. *Foot Ankle Int* 2009 ; 30 : 427-431.
17. **Robinson AHN, Limbers JP.** Modern concepts in the treatment of hallux valgus. *J Bone Joint Surg* 2005 ; 87-B : 1038-1045.
18. **Saragas NP.** Proximal opening-wedge osteotomy of the first metatarsal for hallux valgus using a low profile plate. *Foot Ankle Int* 2009 ; 30 : 976-980.
19. **Sammarco VJ.** Surgical correction of moderate and severe hallux valgus. Proximal metatarsal osteotomy with distal soft-tissue correction and arthrodesis of the metatarsophalangeal joint. *J Bone Joint Surg* 2007 ; 89-A : 2520-2531.
20. **Trnka HJ, Muhlbauer M, Zembsch A et al.** Basal closing wedge osteotomy for correction of hallux valgus and metatarsus primus varus : 10- to 12-year follow up. *Foot Ankle Int* 2003 ; 20 : 171-177.
21. **Veri JP, Pirani SP, Claridge R.** Crescentic proximal metatarsal osteotomy for moderate to severe hallux valgus : a mean 12.2 year follow-up study. *Foot Ankle Int* 2001 ; 22 : 817-822.